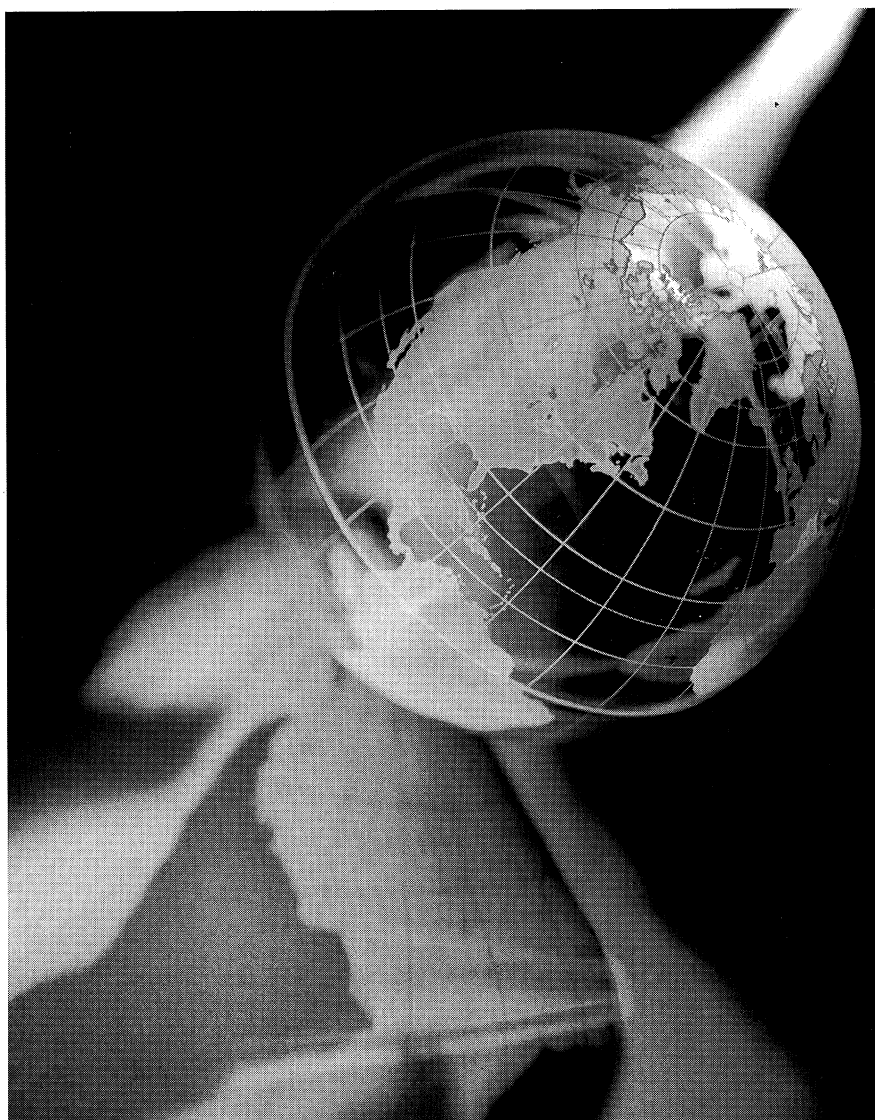


ECONOMIC INTEGRATION IN THE WESTERN HEMISPHERE

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SESSION 5B. INTEGRATION, TRADE AND ENVIRONMENTAL POLICY

Agricultural, Environmental and Health Research in a Global Environment

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This paper is based on the final chapter of a book based on several consultations and a conference involving leading agricultural, environmental, health, and social scientists held during 1989-91.¹ Two perspectives emerged from the consultation and the conference. One is that the battle to achieve sustainable growth in agricultural production must be fought out along a broad multidisciplinary front. Poverty undermines health and degrades the environment. Environmental problems such as soil erosion, water logging and salinity, and fertilizer and pesticide residues link the agricultural agenda with issues such as malaria and schistosomiasis control, sanitation, and water and food quality on the health agenda. Environmental changes underway at the global level, such as acid rain, ozone depletion and climate change will require changes in food production and health practices at the producer and community level. Effective bridges must be built between the "island empires" of the agricultural, environmental and health sciences.

A second perspective is the central role of family and community level decisions in achieving growth of agricultural production, enhancement of the resource base, and improvements in health. This means that much more effective organizational and institutional linkages must be built between the suppliers of knowledge and technology and the users. It also means that the institutions must be designed to place the users in stronger role relative to the suppliers.

During the discussions at Bellagio a vision of the institutional infrastructure that will be needed to supply the knowledge and technology in the areas of agricultural production, resource management, and health began to take shape. In this paper we draw on the papers and discussion at the Bellagio conference and at the three earlier consultations to outline our vision of the structure of global agricultural, health and environmental research systems. We are under no illusion that the process of evolving effective global research system that will be capable of bridging the island empires of agriculture, environment and health will be easy. In his paper for the Bellagio conference Douglass C. North emphasized that the design of an institutional framework that will make possible sustainable agricultural development in the 21st century will require a clearer understanding of the way institutions evolve than is available at the present time.

¹ This paper draws on David E. Bell, William C. Clark and Vernon W. Ruttan. Global Research Systems for Sustainable Development: Agriculture, Health and Environment. In Agriculture, Environment and Health: Sustainable Development in the 21st Century. Vernon W. Ruttan (Ed.) Minneapolis: University of Minnesota Press, pp. 358-80. The dialogues and recommendations from the initial three consultations, held under the auspices of the "Twenty-First Century Project", with support from the Rockefeller Foundation have been reported in three University of Minnesota Department of Agricultural and Applied Economics Staff Papers (Ruttan, 1989; Ruttan, 1990a; Ruttan 1990b). Revised versions of the second and third consultations have been published by Westview Press (Ruttan, 1992, Ruttan, 1992a).

Agricultural Research

This vision is strongly influenced by the experience of attempts, beginning in the late 1950s to establish a global agricultural research system (Ruttan, 1986; Baum, 1986). For the architects of the post-World War II set of global institutions meeting world food needs and the reduction of poverty in rural areas were essential elements in their vision of a world community that could ensure all people of freedom from hunger.

In the immediate post-war years much of the burden fell on the United Nations Food and Agriculture Organization (UN/FAO). But John Boyd Orr, the first Director General of the FAO, burdened with the memory of the agricultural surpluses of the 1930's was highly critical of the view that knowledge and technology represented a serious constraint on agricultural production capacity, "No research was needed to find out that half the people in the world lacked sufficient food for health, or that with modern engineering and agricultural science the world food supply could easily be increased to meet human needs." (Boyd-Orr, 1966:160) in the first two post-war decades assistance for agricultural development in the poor countries was conducted largely in a technology transfer and community development mode. By the late 1950s, it was becoming apparent, however, that the gains in production from simple technology transfer had largely played themselves out.

The inadequacy of policies based on the technology transfer or extension model led, in the early 1960s, to a re-examination of the assumption about the availability of a body of agricultural technology that could be readily diffused from high agricultural productivity to low productivity countries or regions. The result was the emergence of a new perspective that agricultural technology, particularly yield enhancing biological technology, is highly "location specific." Evidence was also accumulated to the effect that only limited productivity gains could be achieved by the reallocation or more efficient use of the resources available to peasant producers in poor countries. The new vision that emerged as a guide to the sources of growth in agricultural production was the product of both experience with the improvement in agricultural technology and a reinterpretation of the role of peasant producers in the process of agricultural development.

It was apparent, in retrospect, that a number of colonial agricultural research institutes had played an important role in increasing the production of several of tropical commodities, particularly export commodities such as rubber, sugar, tea, cotton and sisal. The Rubber Research Institute of Malaysia and the sugar research institutes in Barbados, Java, and India were important examples. The initial success of the Rockefeller Foundation's agricultural programs, initiated in 1943 with the establishment of the Oficina de Estudios Especiales in cooperation with the Mexican Ministry of Agriculture, was of more immediate relevance. The program focused on food crops important in Mexico, particularly wheat and maize, rather than export commodities.

In the early post-war development literature peasant producers had been viewed as obstacles to agricultural development. They were viewed as bound by custom and tradition and resistant to change. In an iconoclastic work published in 1964 Theodore W. Schultz advanced a "poor but efficient" view of peasant producers. They were viewed as making effective use of the resources available to them. But they lived in societies in which productivity enhancing "high pay-off" inputs were not available to them.

Schultz, drawing on the experience of the Rockefeller Foundation program in Mexico and case studies by anthropologists and agricultural economists, identified three "high pay-off" investments needed to enhance

the productivity of peasant producers. These were: (a) the capacity of the agricultural research system to generate locally relevant knowledge and technology; (b) the capacity of the industrial sector to develop, produce and market new inputs which embodied the knowledge and technology generated by research; and (c) the schooling of rural people to enable them to make effective use of the new knowledge and technology.

These insights, from experience and analysis, shaped the response to the food crises of the 1960s and 1970s. The immediate response was the transfer of large resources, including food aid, to the food deficit countries. The longer term response was the mobilization of resources to develop a system of international agricultural research institutes and to strengthen national agricultural research systems (Eicher, Chapter 4).

In 1959 the Ford and Rockefeller Foundations collaborated in establishing an International Rice Research Institute (IRRI) in the Philippines. This was followed by the spinning off of the international activities of the Rockefeller supported Mexican maize and wheat programs to form an International Center for the Improvement of Maize and Wheat (CIMMYT) and the establishment of an International Institute of Tropical Agriculture (IITA) in Nigeria and the International Center for Tropical Agriculture (CIAT) in Colombia. It became apparent by the late 1960s that the financial requirements to maintain the research and development programs of the four institutes were stretching the capacity of the two foundations. In 1969 consultations were held among the Ford and Rockefeller Foundations, the World Bank, the FAO and the United Nations Development program that led to the organization of a Consultative Group on International Agricultural Research (CGIAR). The initial membership consisted of the World Bank, the FAO and the UNDP as sponsors, plus nine national governments, two regional banks and three foundations.

The leadership of the Consultative Group is now centered at the World Bank, which provides a chairperson and a secretariat. Each institute or Center is an independent corporate identity governed by its own board of trustees. The CGIAR established a Technical Advisory Committee (TAC) with its secretariat located at FAO in Rome, to provide technical oversight of the research institutes and to advise the CGIAR on priorities and resource allocation among Venters. The TAC has been charged with the responsibility of organizing comprehensive reviews of the programs of the centers, of evaluating new initiatives, and of overseeing coordination among centers in common program areas such as cropping systems research.

By the early 1990s the system had expanded from an initial 4 to 18 centers. The initial centers focused their research on the major food crops grown in developing countries - rice, wheat, maize, potatoes and cassava. These were joined in the 1970s by centers focusing on livestock production, animal disease and genetic resources, on arid and semiarid areas, food policy, and the capacity of the national research system. At the beginning a commodity orientation in research and development was adhered to in an effort to assure that the limited resources available to the system would not be dissipated in unfocused research efforts.

In the late 1970s and early 1980s crop and farming systems research programs were developed to achieve more effective understanding of soil, water, climate, weed and crop interaction. In the late 1970s several donors to the CGIAR were instrumental in establishing independent research venters to work on soils, irrigation and agro-forestry.

As the new seed-fertilizer technology generated at the CGIAR centers, particularly for rice and wheat, began to come onstream some donors assumed that the CG centers could bypass the more difficult and

often frustrating efforts to strengthen national agricultural research systems. But experience in the 1960s and the 1970s confirmed the judgement of those who had participated in the organization of the international centers that strong national research centers were essential if the prototype technology that might be developed at the international Venters was to be broadly transferred, adopted and made available to producers.

The location-specific nature of biological technology meant that the prototype technologies developed at the international centers could become available to producers in the wide range of agroclimate regions and social and economic environments in which the commodities were being produced only if the capacity to modify, adapt and reinvent the technology was available. It became clear that the challenge of constructing a global agricultural research system capable of sustaining growth in agricultural production required the development of research capacity for each commodity of economic significance in each agroclimatic region. One response by the CGIAR donor community was the establishment of a new Center, the international Service for National Agricultural Research (iSNAR) to provide analytical and technical assistance to national agricultural research systems in strengthening their organization and management.

Another response was, particularly during the 1970s, substantially expanded support for national agricultural research systems. During 1990-92 five new centers were added to the CG system thus increasing the number of Venters from 13 to 18. In 1990 the International Irrigation Management Institute (IIMI), the International Center for Research on Agro-Forestry (ICRAF); and the International Network for the Improvements of Banana and Plantain (INIBAP) were brought into the CG system. In 1992 the International Center for Living Aquatic Research Management (ICLARM) was added to the system. This expansion was not accompanied by an expansion of the resources available to the system. Support to the system in 1990-92 actually declined in real terms producing a "quiet crisis in the system" (Eicher, Chapter 4).

The crisis has not only been financial. A number of the CGIAR centers are experiencing the difficulties associated with organizational maturity. There is a natural "life cycle" sequence in the history of research organizations and research programs (Ruttan, 1982:132). When they are initially organized they tend to attract vigorous and creative individuals. As these individuals interact across disciplines and problem areas the organization often experiences a period of great productivity. As the research organization matures, however, there is often a tendency for the research program to settle into "filling in the gaps" in knowledge and technology rather than achieving creative solutions to scientific and technical problems. Since the early 1980s a number of the managers of several of the CGIAR institutes have been forced to struggle, during a period of budget stringency, with the problem of how to revitalize a mature research organization.

Efforts to strengthen national research institutes have also been only partially successful. The 1970s witnessed a remarkable expansion of agricultural research capacity in a number of developing countries. The national research systems in India, Brazil, Malaysia and a number of other developing countries began to achieve world class status in their capacity to make advances in knowledge and technology available to their farmers. A number of other countries, such as the Philippines, Colombia and Thailand achieved substantial capacity to conduct research on their major agricultural commodities. During the 1990s the buffeting of a global recession and debt crisis had the effect of weakening commitment by a number of aid agencies and national governments to the strengthening of agricultural research. In Africa many national agriculture research systems that have received generous external support even during the 1980s have failed to become productive sources of knowledge and technology. (Eicher, Chapter 4)

The role of technical support for farm decision making by farmers and the capacity to supply to producers the technical inputs in which the new technology is embodied has been a continuing area of controversy. In general the developing countries have been relatively extension intensive. The ratio of extension workers to agricultural product has been much higher in developing countries than developed countries (Judd, Boyce and Evenson, 1987). Weak linkages between research and extension and between extension and farmers have represented a serious constraint on the diffusion of new technology (Tendler, Chapter 6). During the late 1970s and early 1980s the World Bank devoted very substantial resources to the support of an intensive "training and visit" (T & V) system of delivering information about practices and technology to farmers. The system involved a highly regimented schedule in which the field level worker is involved one day each week in intensive training about the information that he or she must convey to farmers (Benor and Harrison, 1977). In retrospect it appears the system erred in placing the extension worker rather than the farmer, or the farm family at the Center of the technology adoption process.

A second constraint on the effectiveness of the transfer of agricultural practices and technology to producers is the weakness of the private sector as a source of both the supply and delivery of knowledge and technology (Evenson, Evenson and Putnam, 1987; Pray, 1987). The emergence of more liberal economic policies since the early 1980s in a number of developing countries is, however, leading to rather rapid growth of private sector suppliers of agricultural technology and to increased research by the suppliers.

The global agricultural support system is still incomplete. The deficiencies discussed by Eicher, Turner and Benjamin, and Tendler in Chapters 4-6 continue to deprive farm families the support that they need to meet even current food consumption and income needs. Yet the vision of the agricultural support system that will be needed to sustain growth in agricultural production is reasonably clear. During the past several decades implementations of the vision have been less than adequate in some developed countries and in all but a few developing countries. With the ending of the cold war it may now be possible to extend the vision to farm families in many of the formerly centrally planned economies. One important step will be to place farm families and the farm enterprise in those societies at the Center of the agricultural production process. Another important step will be to link the agricultural research systems in the formerly centrally planned economies with the emerging global agricultural research system.

Health Research

At the Bellagio conference Godfrey Gunatilleke outlined a vision of the gains in health status that can be achieved by even a poor society that devotes significant resources in support of an effective national health policy. Sri Lanka has achieved health indicators - a life expectancy of around 70 years and infant mortality below 20 per 1,000 live births - comparable to the levels achieved by many societies that are much more affluent. (Chapter 8) But vision of the global health research system needed to sustain national health policy has emerged more slowly than the vision of a global agricultural system. Only within the last decade has the health research community begun to articulate the form that such a system might take.

For most of the last century - since the time of Koch and Pasteur - health research has been thought of principally as laboratory-based biomedical research, seeking "silver bullets" against specific infections or diseases - new vaccines, new drugs, new surgical techniques. This focus, plus the remarkable improvements in health in recent decades, led to the misperception that all the new knowledge and new technology needed to protect families and communities around the world from debilitation and illness could

be generated in the universities, research institutes, and pharmaceutical company laboratories of the industrialized countries.

This limited conception was clearly wrong and has been changing rapidly. Three gains in perception are especially important. The first is the recognition that health technologies, to be useful, must be applied in particular social settings. Achieving health improvements requires not only technology but policies, organizations, and processes that are adapted to the varied economic, social, cultural, and historical circumstances among and within countries. Even vaccines, the simplest of technologies, cannot be applied in Lagos by the same means they are in Liverpool.

An effective health research system, capable of conducting the essential national health research described by Lucas in Chapter 7, needs epidemiologists, economists, management specialists, and other social and policy analysts in addition to biomedical scientists. Such skills are scarce in industrialised countries. They are grossly deficient in developing countries. But they are essential to identify the precise nature of health problems in different national and local settings, and to design, test, and apply appropriate solutions.

A second gain in perception is the recognition that the principal actors in achieving improvements in health are individuals and families, especially mothers. Preventing illnesses and promoting health depends first and most of all on "maternal technology" the ability to use basic knowledge about nutrition, cleanliness, home remedies, and when and how to call on health professionals. (Mata, 1988)

An effective health research system, therefore, must be organized not simply to serve physicians but to support the flow of health knowledge and technology to families and communities - and to provide for the reverse flow of information from families and communities to researchers about the actual nature of health problems and how they are changing. Such a conception of linking researchers directly to primary actors is customary in agriculture, where research results have long been aimed at farmers as decision makers. But it is a recent conception in health even in industrialized countries.

A third gain in perception is the recognition that the world's health research efforts are overwhelmingly concentrated in industrialised countries, seeking technologies to address the diseases of the more affluent societies. Only about five percent of global health research financing is directed to the major diseases and health problems of the less developed countries, where more than 90 percent of the world's burden of preventable deaths occur (Commission on Health Research for Development, 1990). An effective global health research system must address this huge imbalance, and provide for a large increase in the resources devoted to the health problems of the developing countries.

Combining these three perceptions with the traditional power of biomedical research, one can begin to perceive, dimly, the shape of a global health research system and hots to move toward it.

Such a system - in health just as in agriculture - will need to be based solidly on national research systems, capable of supporting decision makers as they identify and confront health problems. A national health research system requires first of all skills to determinants of disease, disability, and death, and to monitor changes in health status over time. It requires also skills to design, test, and evaluate means for applying improved health technologies in local environments, and for making research results available to those who need to use them, from national policy makers to local families. Every nation needs the capacity to conduct such country specific research to guide its health activities, and the establishment of such capacity should clearly be given top priority. (Chapter 7)

Beyond the capacity for essential country specific research, health scientists in every country will wish to join, as and when they can, in the international effort to advance the world's frontiers of knowledge on the social and biological pathologies of ill-health and disability, and on new technologies to overcome them. In poor countries, the conditions for world-class science are difficult to establish. Nevertheless, a significant number of developing countries - to name just a few, Thailand, India, Egypt, Mexico, Brazil - are beginning to have the capacity to make significant contributions to world knowledge in the health field.

Thus, national health research systems need to begin with the capacity to guide national health activities, and to go on, as conditions permit, to participate in global frontier research. In most developing countries, there are only rudimentary health research capabilities at present. It is urgent for developing countries, and for the international health assistance community, to commit themselves to building steadily stronger national health research systems. Such systems will need to start small, and to focus initially on the most pressing health problems. But they should be designed with a view to dynamic change over time as financial and personnel resources grow, and as health problems change with the demographic and epidemiologic transitions through which the developing countries will pass over the coming decades.

Thinking about how to achieve an effective global health research system thus begins with the development of strong national systems. But national systems must not be thought of as separate, free-standing entities. On the contrary, it is essential that they be linked together by strong international ties, and draw from the common, growing pool of world-wide health knowledge, with each country adapting advances in health science to its own specific circumstances.

Moreover, it would be a mistake to think of a global system as centered in the industrialised countries, with all scientific advances pioneered there and rippling outward to the developing world. We have already seen major health improvements developed in the Third World, as ambulatory therapy for tuberculosis was pioneered in Madras, and oral rehydration therapy for diarrhea in Dhaka. As the amount and quality of developing country research steadily rise, a global research system will increasingly be multi-centric - one in which the flows of ideas and new knowledge move in all directions along networks of information and collaboration encompassing scientists from many countries rich and poor alike.

Thus the guidelines for moving toward a global health research system include the development as rapidly as feasible of strong national systems, especially in developing countries where they are currently very weak, and (2) the rapid evolution of international collaborative mechanisms and arrangements. There is much work here for years to come.

In the discussions at Bellagio, two aspects of this overall vision received special attention and illumination.

The first was the necessity for building direct relationships between the national health research system and action for health at the community and family level. In Chapter 8, Dan C. O. Kaseje describes the elements of a community based health system in Kenya that he helped design and implement that relies directly on the actions of individual families and communities. The model views the mother as the key health provider. It builds on the strong motivation to carry out her tasks resulting from concern about the current and future well-being of her children and family. Kaseje summarizes the concept behind the "Harambee" model:

This model recognizes the strengths and resources of the community; seeks to facilitate and enhance these strengths; recognizes that communities have always been responsible for their own health, even without the intervention of health professionals that the mother is the most important and knowledgeable health

provider. This mother is not, however, left without resources to carry out her responsibilities. She is reinforced with a strong program of health education, the availability of appropriate technology materials, and support from NGO and official health programs. The system described by Kaseje does not work perfectly. It should not be overly idealized. Kaseje himself expressed considerable skepticism that it will be possible to boost the professional and bureaucratic inertia needed to extend and sustain the program he has described.

It is clear, however, that the resources needed to enable the family to provide effective health services to its members are very similar to those identified three decades ago by Schultz to enable peasant producers to become effective suppliers of agricultural commodities. The "high pay-off" health inputs include:

(a) The capacity of the health research community to produce the new knowledge and the materials that are appropriate to the resource and cultural endowments of rural communities.

(b) The capacity of national, regional, and local institutions to make the knowledge and the materials available to families; and

(c) The formal schooling and informal education of families, particularly mothers, to make effective use of the knowledge available to them.

The second issue on which the papers and discussions at Bellagio shed light is the nature of the international apparatus needed for a global health research system.

In the field of agriculture, the CGIAR sponsored set of international research centers serve as leaders of applied science for the Third World and accelerators of linkages between frontier science and Third World problems. There is no comparable set of internationally supported health research centers in poor countries of the tropics.

Adetokunbo Lucas in his paper (Chapter 7) notes that there are only two international centers of significant size in the field of health - the International Centre for Diarrheal Disease Research, Bangladesh, and the International Centre for Insect Physiology and Ecology in Kenya (which is concerned with entomology that is relevant to both health and agriculture).

There are strong differences of opinion within the international health community as to whether a system of international health research centers, analogous to the CGIAR centers, would be appropriate or effective.

On the one hand internationally organized efforts have the advantage of achieving a critical mass of scientists concentrating on and physically located close to high priority problems... Internationally organized research efforts can focus on specific problems in a multidisciplinary way and demonstrate economies of scale in their operations, making them attractive to external funding. On the other hand, international center salaries are high and their activities, if not carefully targeted, can supersede rather than complement national efforts (Commission on Health Research for Development, 1990:58).

At the Bellagio conference there was something approaching consensus that present constraints on foreign assistance funds suggest that it would be unrealistic to expect that resources could be mobilized in the mid-1990s to support a system of international health research centers in the tropics. It seems more likely

that the predominant model of international collaboration in the health field will be international networks linking scientists in national institutions (both in industrialised and developing countries) in goal oriented research programs aimed at specific health problems. A successful example of such collaboration is the Special Programme for Research and Training in Tropical Diseases (TDR), co-sponsored by UNDP, the World Bank, and WHO. Started in 1976, TDR focusses on six specific diseases, (including malaria, schistosomiasis, and leprosy), and in addition to supporting research, invests approximately 25 per cent of its annual budget of \$30-35 million in strengthening research capacity in developing countries.

While international networks of national centers evidently can work effectively in supporting research on particular diseases, there is one extremely important function they cannot perform. The field of health research conspicuously lacks an overview mechanism. In agriculture, the CEDAR (as distinct from the set of centers it sponsors) has built highly valuable methods for surveying the world-wide agricultural research scene in relation to the needs for research results, reviewing on-going research activities (both those of the international centers and of other institutions), and proposing changes in current research priorities and institutional arrangements including where necessary the development of new research facilities.

There is no analogous, effective, independent organization in the health field for assessing progress in research, especially on developing country health problems identifying neglected areas, and promoting necessary action. The result is clear. At present, of the three leading infectious disease causes of death in the world (acute respiratory infections, diarrheal diseases, and tuberculosis), only diarrhea is addressed by a major, sustained research effort. That is why the Commission on Health Research for Development came to the conclusion that "a health analogue of the CGIAR assessment and promotion structure could be of great value and should be established (Commission on Health Research for Development, 1990:59). This objective is clearly an urgent one.

Environmental Research

If the global research system for agriculture now faces the challenges of maturity and the system for health confronts those of adolescence, then the global environmental research system still requires pre-natal care.

To be sure, research for environmental conservation has a long and productive history in many parts of the world. Since World War II, this research has been given impetus and direction by at least three waves of concern over the implications of natural resource availability and environmental change for the sustainability of improvements in human well-being. Early work focussed on the adequacy and protection of the material base for agricultural and industrial production. By the mid 1970s, increasing attention was also being given to the impact of residuals generated by that production on air and water quality and human health. Today, rapidly growing awareness of global change in the earth system had provided yet another dimension to our environmental concerns.

Most environmental research to date has been performed in universities, initially with support from major philanthropic organizations such as the Ford Foundation. Prodded by the Stockholm Conference on the Global Environment in 1972, national governments have become increasingly involved as supporters, producers, and users of environmental research. Over the last decade, there has also been an explosion in the number and variety of non-governmental organizations active on the world's environmental scene, some of them producing research of the highest calibre and relevance (Livernash, 1992). International programs for environmental research have also expanded dramatically since their "modern" birth in the International Geophysical Year of 1957. Nonetheless, most important international institutions for environmental

research are barely 20 years old - for example ICSU's SCOPE, UNESCO's MAB, IIASA and, of course, UNEP (Caldwell, 1990). Today's major research programs on global change - the World Climate Research Program (WCRP), the International Geosphere Biosphere Program (IGBP), and the Human Dimensions of Global Change Program (HDGEC) - are younger still (Jaeger and Ferguson, eds. 1991; Miller and Jacobson, 1992; Perry, 1991).

This impressive and expanding array of activities nonetheless fails far short of the global system of environmental research needed to provide the knowledge base for sustainable development. Still lacking is a coherent institutional structure that can link the world's environmental researchers both upward to the international level of policy negotiations and downward to the community level consumers producers, health workers and extension agents on whose actions sustainable development must ultimately depend. In the wake of the Rio "Earth Summit", however, several initiatives are under discussion that could supply important components of such a system and move it substantially closer to reality.

The most ambitious of these is START - a System for Analysis, Research and Training proposed in 1991 by the IGBP in collaboration with the WCRP and HDGEC. START is planned as "a global system of regional research networks to stimulate research, modelling, and training activities related to global [environmental] change in both the natural and social sciences" (IGBP, 1992; p5). Its regional focus is based on the realization that global change wears local faces. The origins, the impacts, and the options for managing global environmental change will be different in different parts of the World, and must be understood within their local environmental and social contexts. The initial START planning document divided the world into 13 "scientifically coherent" regions (Eddy et al., 1991). Within each region, the research network is planned to consist of one or more research centers plus an unspecified number of regional research sites (eg. university departments, field stations). The networks aim to provide scientists from all parts of the world the knowledge and infrastructure necessary for them to participate fully in on-going research concerning global environmental change. If planned funding from the international community is forthcoming, the first of the networks - probably in the Tropical Asian Monsoon region - could be fully operational by mid-decade.

In addition to the comprehensive plans of START, a number of more focussed regional initiatives are also being pursued around the world. For example:

- * Asia: The Smithsonian-sponsored program on Sustainable Management of Tropical Evergreen Forests has linked leading centers throughout Asia in a unique network for research, training and data collection (Ashton, 1991). Though the tropical forests program has been launched largely through the efforts of private foundations and host-country contributions, Japan and the United States - through their recently announced "Global Partnership Plan of Action" - have promised increased governmental support of environment and conservation research in the region (Lepkowski, 1992).

- * The Americas: The Inter-American Institute for Global Change Research (IAI) has been established as a "regional network of research entities... [that] seeks to achieve the best possible international coordination of scientific and economic research on the extent, causes, and consequences of global change in the Americas" (IGBP, 1991; Declaration of Montevideo, 1992). Close integration with the START initiative has been emphasized throughout the planning of the IAI.

- * Central and Eastern Europe: A number of environmental research, development and training institutions have been formed to address the special problems of this region. One notable example with support from

a number of western countries is the Regional Environmental Center in Budapest. Since its inception in 1989, the Center has helped "to set up environmental surveys, grassroots and non-governmental organizations, new environmental legislation and remediation campaigns" (Nature 1992). Its major activity has been building a data base on environmental conditions in the region, coupled with a computer network to disseminate these data to smaller offices for use by local researchers.

* Globally: Increasing attention is being given to the need for a permanent international research institution that could tackle environmental problems that transcend individual regions, and link national centers for environmental research into a truly global system. This function is currently performed on a largely ad-hoc basis - for example through studies of ICSU's Scientific Committee on Problems of the Environment, or the Intergovernmental Panel on Climate Change. But the time may well be ripe for complementing such ad hoc efforts with a more permanent home or homes. The International Institute for Applied Systems Analysis, with its focus on problems of global change (IIASA, 1991), has been put forward as one leading candidate (Maddox. 1992).

How these and other initiatives will relate to one another or to existing national research centers is not yet clear. Most of the parties involved seem aware of the need for addressing such relations. Early indications are that their potential complementarities could dominate the inevitable competition for people, programs and funds. The recent formation of a professional secretariat for START in Washington can only improve the prospects for successful integration of emerging international environmental research efforts.

Against this optimistic assessment, however, it must be noted that in the dialogue leading to recent environmental research initiatives there appears to have been little consideration of appropriate linkages with agricultural and health research systems. (Chapters 10-12) This is a serious omission for two reasons. First, it virtually guarantees that many of the lessons painfully learned in the course of building today's relatively mature network of agricultural and health research systems will be lost on the fledgling environmental effort. Second, it perpetuates the "island empire" problems we referred to at the outset of this essay. We address possible measures for mitigating these shortcomings in turn.

First, there are several related lessons from the development of today's agricultural and health research systems that should be incorporated in new environmental efforts. As noted above, all of these reflect a growing appreciation of the central role of family and community level decisions in shaping sustainable development:

*Means must be designed to assure that research priorities reflect the environmental problems confronting individual families, farmers, and resource users in the field. The small "charmed circle" of puzzles that excite lab scientists or program administrators should not be allowed to dominate the agenda. The World Bank's recent report on Development and the Environment (World Bank, 1992) is surely correct in its conclusion that "the current environmental debate has paid too little attention to the problems of clean water, urban air pollution, indoor air pollution, and severe land degradation" that each year kill millions of people, undermine the health of hundreds of millions more, and significantly reduce productivity of people who can least afford it (World Bank, 1992, p.4; see also Norberg-Bohm et al., 1992).

* We must resist the temptation to search for universal "silver bullets" that will solve specific environmental problems whenever and wherever they occur. Most causes, impacts and solutions will be intimately associated with particular social circumstances and landscapes. Effective research systems will therefore require significant site specific components, and must avoid focussing activity in a few elite

laboratories of the high income countries. The need for elite laboratories will remain, in part because of needs for special research and data processing equipment, in part because of the need to bring in top scientists from many disciplines together for particular aspects of the necessary research. But specific measures must be implemented to assure that such regional centers do not bleed talent, funds and equipment from the essential national and local nodes of the research network. A recognition of the need for simultaneous and complementary strengthening of the local, national and regional dimensions of the emerging global environmental research system seems well embodied in the plans for START (Eddy et al., 1991). But a practical vision of "essential national environmental research" - how it is to be funded and linked to international efforts - has yet to emerge.

* A "technology transfer" strategy for research and development will be no more successful in dealing with environmental problems than it has been for sustaining improvements in agricultural productivity or human health. This applies not only to conventional north-south transfers, but also to the current spate of enthusiasm for grafting the clean energy systems of advanced OECD nations onto the formerly socialist economies of Europe. Less obviously, but perhaps even more importantly, experience in the agriculture and health sectors warns against the wholesale transfer of institutions as a means of enhancing environmental conservation. This is especially the case in the area of common pool resources, where an uncritical tendency to transfer solutions based on full private property rights or centralized regulation to small scale, low income situations has had disastrous consequences. Appropriate alternatives often exist, more finely attuned to local social and environmental conditions (Ostrom, 1990). In general, the need is not to transfer environmental technologies and institutions from "advanced" to "developing" regions, but rather but to promote more widespread sharing of knowledge, know-how and experience around the world. In particular, in environment as in agriculture and health, the need is to enhance the voice and power of users relative to suppliers of needed research and development.

* An effective global environmental research system must be much more broadly inclusive than is presently the case. The need to better incorporate knowledge users in the system has been stressed in this chapter. The need for an expansion of the capacity to monitor global change has been emphasized in Chapters 10-12. The environmental R&D potential of the formally centrally planned economies must also be tapped though this will require institutional innovations to end the traditional exclusion of such societies from the "global" research system. Finally, the private sector must be encouraged as both a supplier and deliverer of the knowledge needed for environmentally sustainable development. Perhaps no single factor has so inhibited the development of effective global research systems for agriculture and health as the failure to promote incentive and reward structures that can induce constructive private sector involvement. In the environmental field, there is a vast potential for private sector engagement in topics as diverse as energy efficiency to biotechnology. But a number of issues involving intellectual property rights, liabilities, and government-industry relations will have to be resolved before the potential can be fully tapped for the benefit of sustainable development (Schmidheiny, 1992).

In summary, an effective global environmental research system will have many of the features of effective agricultural and health research systems, the behavior of consumers of environmental services and the producers of the residuals - households, farms and factories - that erode environmental amenities will have to be recognized as central to the process of environmental change (Chapter 5). The resources that will be needed to place households, farms and factories in a position to respond constructively will depend on: (a) the capacity of the environmental research system to provide the knowledge, including the essential national environmental research, needed by household, farm and factory decision makers; (b) the capacity of national, regional and community institutions to provide the knowledge, technology and incentives to those

who make decisions about resource use; and (c) the depth of understanding possessed by household, farm and factory decision makers about the consequences of their own actions and the actions of the economic and political institutions in which they participate.

Bridging the "Island Empires"

We have argued that the "island empires" of the agricultural, health, and environmental sciences can learn from one another as they strive to build global research systems that can support sustainable development. Whether they can, or even should, move beyond passive learning to active cooperation remains to be seen.

There seems little merit in any grand organisational scheme that would attempt to pull the already diverse networks of research in the respective empires under a single roof. And the most dynamic of the existing empires - that dealing with environmental research - simply does not have enough experience in the tough business of actually running a global network to seem credible as a leader of any major bridging movement. What does seem both feasible and desirable, however, is to begin some modest effort at active bridge building.

At a minimum, the principals of the three empires might agree to meet regularly - perhaps in the spirit of the G-7 Summits - in order that they and their senior staff members could get to know one another and exchange information on current activities. An exploration of possible collaboration in global monitoring and other data gathering activities might be a good early agenda item for such meetings. The new UN Commission on Sustainable Development, established at the 1992 "Earth Summit", would be one logical convener for such meetings. But private foundations and NGOs could do a lot to get the ball moving.

At a deeper level, it is essential to realize that the global agricultural, health and environmental research systems outlined in this chapter have important common elements. The global systems outlined in this chapter can be effective only as the underlying sciences - particularly the biological and the social sciences - advance. Advances in the biological sciences and the social sciences are necessary to enlarge the world's understanding of the natural and social phenomena in global change. They are also needed in order to expand the capacity to apply advances in knowledge to the national and human dimensions of development in the poor countries where most of the world's people live.

The need to enlarge scientific capacity in the poorer countries of the world should not be viewed as a burden on either the developed or developing countries. Rather it is an opportunity to multiply the intellectual talent necessary to advance knowledge relevant to the achievement of sustainable development. Completion of the development of global research systems in agriculture, health and environment is a necessary component of a global effort to establish and mobilize the intellectual capacity and energy that will be needed to sustain development.

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